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(54) **Apparatus for introducing gas into a rapid thermal processing chamber**

Vorrichtung zum Zuführen von Gasen in eine schnelle Wärmebehandlungskammer

Appareillage pour alimenter un gaz dans une chambre à traitement thermique rapide

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[0001] The invention relates generally to rapid th r-mal processing chambers.

[0002] Typically, rapid thermal processing systems utilize a high intensity light source to rapidly heat a substrate that is held within a processing chamber, sometimes under vacuum conditions. The light source, which may consist of an array of high intensity lamps, is located outside of the chamber and adjacent to a window through which the light passes into the chamber. Inside of the chamber and on the other side of the window, the substrate is supported in such a manner that it can be heated by the incoming light. In some systems, the substrate is supported on a susceptor and it is the susceptor that is directly heated by the light. In other systems, the substrate is supported by a support ring which leaves both the front and back of the wafer substantially exposed to the atmosphere in the chamber and it is the frontside of the substrate which is directly heated by the light. The wavelength of the light is selected so that it is substantially absorbed by the substrate or the system component that is being heated and the material of which the window is made is selected so that it is substantially transparent to the light. Often, quartz is used for the window.

[0003] Two systems which utilize support rings are described in greater detail in U.S. Patent 5,155,336 and U.S. Patent Application Serial Number 08/359,302, filed 12/19/94.

[0004] For many processes that are performed within the chamber (e.g. deposition, etch, epitaxial processes, doping, growing oxides, nitridation, etc.), it is necessary to deliver a process gas into the chamber.. Moreover, the process gas must be delivered so as to produce substantially uniform results over the surface of the wafer. One approach that has been used is to inject the gas to the side of the substrate and let it flow over the surface of the substrate (see U.S. 5,155,336 referenced above). Another approach has been to use a showerhead that is positioned adjacent to the substrate and on the side of the substrate that is opposite the side that is being heated by the high intensity light (see U.S.S.N. 08/359,302 also referenced above). Though these and other various approaches to gas injection do exist, there is always a need to improve upon them.

[0005] WO 90/14158 discloses a showerhead for use with a lamp head in a thermal processing chamber, the lamp head including a high intensity source which emits radiation that heats a substrate within the chamber, said showerhead comprising: a top window on a side of the showerhead that is, in use, adjacent to the lamp head; a bottom window on a side of the showerhead that is, in use, adjacent to the substrate during processing; and a gas supply inlet through which a gas is introduced into a space between the top and bottom windows, wherein the top and bottom windows are transparent to the radiation from the source in the lamp head and wherein the bottom window includes a plurality of gas distribution holes through which gas is injected from the space between the top and bottom windows, in use, into the chamber.

[0006] According to a first aspect of the present invention, such a showerhead is characterised by a coolant structure providing a coolant flow path, at least a portion of which traverses and is in thermal contact with the bottom window.

[0007] According to a second aspect of the present invention, there is provided A method of processing a substrate in a thermal processing chamber comprising the steps of: providing a top window and a bottom window, wherein said top window is proximate to a light source and said bottom window is proximate to the substrate in the chamber; directing radiation from the light source through the top and bottom windows and onto the substrate within the chamber to heat the substrate, wherein both the top and bottom windows are transparent to said radiation; and while directing radiation through said top and bottom windows, also introducing a gas between the two windows and into the chamber through gas distribution holes in the bottom window; characterised by, while directing radiation and introducing said gas into the chamber, also flowing a coolant transversely across and in thermal contact with the bottom window.

[0008] Preferred embodiments include the following features. The top and bottom windows are made of quartz. The showerhead also includes a top plate with a plurality of holes; a bottom plate with a plurality of holes equal in number to the plurality of holes in the top plate; and a plurality of tubes equal in number to the plurality of holes in the top plate. Each of the plurality of tubes connects a different one of the holes in the top plate to a corresponding one of the holes in the bottom plate. In addition, the top window is adjacent to the top plate and the bottom window is adjacent to the bottom plate, Furthermore, at least one of the top and bottom plates has an array of channels formed therein for distributing the gas to the holes in the bottom window. Also, the top and bottom plates and/or the tubes are made of stainless steel or aluminum and the tubes are coverd on their inside surfaces with a highly reflective material, e.g. gold.

[0009] Also in preferred embodiments, the showerhead includes a coolant inlet and a coolant outlet, and wherein during operation a coolant is circulated through the showerhead from the coolant inlet to the coolant outlet. Also, the showerhead is designed so that the coolant contacts the outside of the tubes.

[0010] In general, in still another aspect, the invention is a thermal processing system including a chamber defining a processing cavity; a lamp head; a showerhead positioned between the lamp head and the processing cavity in the chamber; and a substrate support mechanism within the chamber and spaced apart from the adapter plate. The showerhead is constructed as described above.

[0011] In preferred embodiments, the showerhead is mounted between the lamp head and the chamber. Also, the thermal processing system further inclludes a rotational drive which rotates the substrate support mechanism during processing and a reflecting plate located beneath the support ring which with a backside of the substrate defines a reflecting cavity. In addition, the substrate support mechanism includes a support ring which holds the substrate at locations around its perimeter.

[0012] The invention makes it possible to perform CVD in an RTP chamber in which the substrate is heated by lamp radiation from the top side of the substrate. With the invention, reactant gases are introduced into the RTP chamber through a quartz plate which also serves both as a low pressure adapter plate and as a window through which the high intensity radiation can enter the chamber to heat the substrate. The gas that is distributed through this plate flows out through holes that are radially distributed over the plate above the entire wafer surface. The invention combines the benefits of RTP (e. g. excellent temperature uniformity, fast heating, and fast gas switches) with uniform gas distribution associated with showerhead gas injection. The resulting uniform gas distribution in conjunction with a rotating substrate produces improved film uniformities at higher wafer throughputs.

[0013] Another benefit of the invention is that it is readily scalable to larger wafer diameters. In addition, this method of gas introduction provides a further way of cooling the quartz window that is being heated by the high intensity lamps. The added cooling will further reduce the tendency for deposits to form on and/or in the adapter plate and it will thereby contribute to minimizing the need to clean the adapter plate using reactive gases, e.g. HCl.

[0014] The invention also provides a way of introducing reactive and/or process gas into the RTP chamber without significantly impacting the thermal characteristics of the chamber. This becomes even more significant in system designed to process larger wafer diameters, e.g. 300 mm and larger.

[0015] Other advantages and features will become apparent from the following description of the preferred embodiment with reference to the accompanying drawings, in which:

Fig. 1 is a schematic representation of an RTP chamber;

Fig. 2 is a schematic representation of an RTP chamber showing the components of a magnetic drive for rotating the support ring and the substrate;

Fig. 3 is a side, cross sectional view of the adapter plate;

Fig. 4 is a top view of the adapter plate;

Fig. 5 is bottom view of a multi-zone showerhead;

Fig. 6 is an example of an dual-zone adapter plate;

Figs. 7a and 7b show two examples of other multi-zone showerhead designs; and

[0016] Referring to Fig. 1, a representative RTP chamber 10 includes a chamber body 12 which defines an internal processing cavity 14 in which a substrate 16 is held during processing. The substrate is typically a semiconductor wafer (e.g. silicon) although it could be made of other materials and could have shapes other than wafer form. For example, the substrate could be a glass plate such as is used to fabricate display screens.

[0017] At the top of the chamber there is a heat source which is used to irradiate substrate 16 with a high intensity radiation (e.g. light) and thereby rapidly heat substrate 16 to the desired processing temperature. The heat source includes a lamp head 40 and an adapter plate 42 which functions as an interface between lamp head 40 and chamber body 12. Lamp head 40 contains an array of tungsten-halogen lamps 44, each of which is housed in a tube 46 which has its inside plated with highly reflective gold. To cool lamp head 40 during use, water is circulated through the head in the spaces between tubes 46. The details of the design and construction of such lamp heads can be found elsewhere and thus will not be presented here. Refer, for example, to U.S. Patent 5,155,336 to Chris Gronet et al., entitled "Rapid Thermal Heating Apparatus and Method".

[0018] Adapter plate 42 performs multiple functions. It provides a window through which the high intensity radiation light from lamp head 40 can pass into the chamber. It functions as a vacuum barrier between lamp head 40, which is at atmospheric pressure, and the inside of chamber 12, which is typically brought to low pressure or vacuum conditions at some point during the process. It also provides structural support for the window material thus enabling one to use relatively thin material without risk of it breaking under the forces caused having atmospheric pressure on one side of the window and a low pressure or vacuum on the other side. This is especially important for the larger systems that are now being considered for processing substrates that are 300 mm and larger. Finally, it also functions as a showerhead through which gases, e.g. process and/or reactive gases, are injected into the chamber during processing.

[0019] Inside cavity 14 there is a support ring 18 which holds substrate 16. Support ring 20 is annular shaped and includes an inwardly extending lip 24 which holds substrate 16 at its outer perimeter thereby leaving most of the substrate's backside exposed. The transition from the lip 24 to the outer portion of support ring 18 defines a shoulder which holds the substrate in place as support ring 24 and tube 20 are rotated during processing.

[0020] Beneath substrate 16 there is a reflector plate 28 which is mounted on a water-cooled, stainless steel base 31. Reflector plate 28 is made of aluminum and is coated with a highly reflective material, e.g. gold. Support ring 18 holds substrate about 0.5 inch above a bottom reflecting plate 28 to form a reflecting cavity 35 between the underside of substrate 16 and the top of reflector plate 28. Passing up through the bottom of the chamber are one or more light pipes 30 which are used

to sample the radiation within reflecting cavity 35. The sampled radiation from each light pipe is passed through a corresponding optical fiber 32 to one or more pyrometers 34 which convert the intensity of the sampled radiation to a substrate temperature reading. Reflecting cavity 35 serves to enhance the effective emissivity of the substrate and thereby produce more accurate temperature measurements which are less sensitive to variations in emissivity from one wafer to the next. Control circuitry (not shown), which receives the temperature-readings from pyrometers 34, regulates the power to lamp head 40 to achieve the desired substrate temperature during the processing cycle.

[0021] Support ring 18 rests on top of a rotatable tubular quartz cylinder 20 which is rotated by a magnetically coupled drive mechanism 22 (see Fig. 2) coupled to the bottom of cylinder 20. Cylinder 20 is coated with silicon to render it opaque in the frequency range of the pyrometers. The silicon coating on the quartz cylinder acts as a baffle to block out radiation from external sources that might contaminate the intensity measurements.

[0022] The magnetic drive mechanism, an example of which is illustrated in Fig. 2, includes an annular upper bearing race 23 which rests on a plurality of ball bearings 25 that are, in turn, held within an stationary, annular, lower bearing race 27. The ball bearings 25 are made of steel and coated with silicon nitride (or alternatively, solid silicon nitride) to reduce particulate formation during operation. The bottom of the quartz cylinder is held by upper bearing race 23 which is magnetically-coupled to an actuator 29 which rotates cylinder 20, support ring 18 and substrate 16, e.g. at about 90 RPM or faster, during thermal processing. Further details on the system shown in Fig. 2, can be found in U.S. Patent Application serial number 08/359,302, filed 12/19/94, entitled "A Method and Apparatus for Measuring Substrate Temperatures".

[0023] Referring to Figs. 1 and 3, adapter plate 42 is made up of a plurality of hollow tubes 48 sandwiched between two quartz windows, namely, a top window 50 and a bottom window 52. Tubes 48 of adapter plate 42 align with tubes 46 in lamp head 40 when the two units are mounted on top of chamber 12. Tubes 48, which also have their insides plated with a highly reflective gold, are held at the top and bottom ends by a top plate 54 and a bottom plate 56, respectively, all of which are made of metal, e.g. stainless steel or aluminum. Top and bottom plates 54 and 56 have an identical array of holes in them. Each of the holes is slightly larger than the outside diameter of the tube. The ends of each tube rest in corresponding holes of the top and bottom plates and are welded in place.

[0024] Both top window 50 and bottom window 52, which rest against top and bottom plates 54 and 56, respectively, are made of a material that is transparent to the wavelength of the radiation that is emitted by the lamps (e.g. quartz). Around the perimeter of top plate 54, there is a groove with an O'ring 58 that forms a vacuum seal between top window 50 and top plate 54. Similarly, around the perimeter of bottom plate 56, there is another groove with another O'ring 52 that forms a vacuum seal between bottom window 52 and bottom plate 56. Top window 50 provides a vacuum barrier between the lamp head which is at atmospheric pressure and the inside of the adapter plate, which is typically at reduced pressure during processing (e.g. a pressure that is higher than the chamber pressure but lower than atmospheric). In contrast, bottom plate 52 includes an array of holes 60 which are clustered in locations adjacent to tubes 48. Thus, gas which is injected into adapter plate 42 passes out through these holes into the chamber.

[0025] Fig. 4 shows a top view of adapter plate 42 as seen from the perspective of lamp head 40. Across the top of top plate 54 there is a crisscrossing, hexagonal array of milled channels 80. In this described embodiment, the crisscrossing array of channels is formed by milling three separate grids of channels across the plate, each grid made up of parallel milled channels equally spaced across the surface of plate 54. Each grid of milled channels is rotated with respect to the other grid by 120°. In Fig. 4, the three separate grids of milled channels are identified by numerals 80(1), 80(2) and 80 (3).

[0026] In top plate 54, the holes which receive tubes 48 are centered on the points of intersection of the milled channels of the three different grids. Thus, for each tube 48 there are six milled passageways radiating radially out from the tube and connecting it to the six nearest neighbor tubes.

[0027] Around the perimeter of top plate 54 there is also a gas supply groove 82 into which all of the milled channels terminate at either end. Gas is supplied to gas supply groove 82 through a gas coupling 84 which is connected to groove 82 through a passageway 86. The gas that is supplied to gas supply groove 82 flows through the milled channels on top of to plate 54 and into tubes 48. The gas within tubes 48 then flows out of the adapter plate through the holes in bottom window 52.

[0028] Generally, it may be desirable to have the distribution of holes in bottom window 52 extend out past the edge of the substrate so as to better approximate a uniform gas distribution. What remains of the process gas, after it passes over the substrate, is then collected by the vacuum system through exhaust ports 71 located near the periphery of the chamber. It may also be desirable to locate the exhaust ports to the side of and below the substrate, as shown, so as to facilitate achieving a more uniform gas distribution over the surface of the substrate. In addition, it is also desirable to utilize an axissymmetric exhaust system design, i.e., exhaust ports distributed around the perimeter of the substrate and to thereby avoid or minimize any angular dependencies in the gas flow.

[0029] In the described embodiment, substrate 16 is

about 1 inch below the bottom quartz window of adapter plate 42. When irradiated with high intensity light, substrate 16 will radiate energy back at the adapter plate 42. The radiated energy will typically have a longer wavelength than the wavelength of the impinging light. Thus, the radiated energy will be absorbed to a great r extent by the quartz and it will heat up adapter plate 42. To remove this heat, . adapter plate 42 is provided with a liquid coolant system. On one side of adapter plate 42 there is a coolant inlet connector 90 and on the other side there is a coolant outlet connector 92. Coolant (e. g. water) is flowed in through connector 90 into a receiving chamber 94 which is coupled to the space 98 between the tubes through three passageways 95. The water, which circulates between the top and bottom plates 54 and 56 and around the outside of tubes 48, cools both tubes 48 and the top and bottom plates 54 and 56. After the water has passed through adapter plate 42 it exits through three passageways 97 on the opposite side, into a chamber 96, and then out through outlet connector 92.

[0030] It may be desirable to include baffles 99 within adapter plate 42 to control the path of the coolant through the inside of adapter plate. The baffles may be complete or partial barriers blocking the passageway between selected neighboring tubes 48. Six such baffles 99 are shown in Fig. 4 for illustrative purposes. The location of such baffles would of course be selected to produce the most effective cooling of the adapter plate.

[0031] During operation, process gas is introduced into adapter plate 42 through gas coupling 34. It flows into supply groove 82 around the perimeter of top plate 54 and into the distribution channels crisscrossing top plate 54. From the distribution channels, it flows into the tubes of the array and then to the distribution holes in bottom window 52. The gas flows out of the distribution holes into the chamber above the substrate that is held in the support ring.

[0032] The described method of distributing gas to the holes in the bottom window of the adapter plate is, of course, an implementation detail. The described embodiment is meant to merely be illustrative of one of many possible alternative approaches which could be used. For example, if milled channels are used to distribute the gas, the channels could be milled into the bottom surface of bottom plate 56 (i.e., the surface which is contact with bottom window 52). In that case, it would not be necessary to cluster the gas distribution holes in bottom window 52 within areas the are circumscribed by tubes 48. Alternatively, other plumbing arrangements could be used to deliver the gas to the backside of the bottom window. Though with any approach it is desirable to minimize obstructions to the light passing through the adapter plate into the chamber. Also, in general, it is probably desirable to design the adapter plate so that the conductance of the passages delivering gas to the faceplate much higher that the total conductance of holes through the faceplate. In that case, the number, size, and distribution of holes will have less impact on the flow rates through the holes near the center region of the bottom window.

[0033] Also, it may be desirable to vary the sizes of the holes and their distribution in ways that are known to persons skilled in the art so as to adjust and/or tailor the flow of process gas over the surface of the substrate. It may also be desirable to inject the gas at several places around the perimeter of the adapter plate. For example, in Fig. 4, two injection points are illustrated on opposite sides of the adapter plate from each other. This will assure a greater uniformity of the conductance of the gas that is supplied to the distribution holes in bottom window 52. In addition, one could also modify the size of the channels as a function of location or distance from the center of the plate to ensure fresh gas is introduced over the entire wafer surface and to counter possible gas depletion effects.

[0034] In the above-described embodiment, gas from a single source is supplied to all of the holes in the bottom window or distribution plate. In other words, all of the tubes 48 and thus all of the gas distribution holes in bottom window 52 are interconnected by the same crisscrossing array of milled channels. Alternatively, the adapter plate can be designed and constructed so as to define two or more sets of independently fed gas distribution hole arrays in bottom window 52. For example, in a dual zone gas showerhead 100 such as is illustrated in Fig. 5, there are two hole arrays, namely, an inner hole array 102 and an outer hole array 104. One source of gas (not shown) feeds gas to the inner hole array 102 through a first inlet port 103 and a second independent source of gas source (not shown) feeds gas to the outer hole array 104 through a second inlet port 105. With this configuration, it is possible to independently control the flow rates through the two gas distribution hole arrays and thereby have greater control over the contour of the gas flow distribution over the surface of the substrate. In addition, by supplying the inner array of gas distribution holes separately from the outer array of gas distribution holes, as illustrated, it becomes possible to modify (e.g. increase) the conductance of the gas delivered to the holes near the center of the showerhead without affecting the conductance of the gas delivered to the holes in the outer array. Conversely, the flow of gas through the holes of the inner array will not be influenced by the number, size, and distribution of holes in the outer array.

[0035] A multi-zone showerhead configuration can be implemented in the adapter plate by simply milling the gas distribution channels appropriately. For example, referring to Fig. 6, a dual zone adapter plate showerhead is shown. Note that the water cooling couplings are not shown so as to simplify the drawing. It should be understood, however, that water cooling is also provided in this adapter plate as in the case of the adapter plate shown in Fig. 4.

[0036] The tubes 48 in the adapter plate of Fig. 6 are

divided into two groups, namely, an inner group 202 and an outer group 204. For clarity, th tubes of the inner group have been labeled with "A" and the tubes of the outer group are either unlabeled or are labeled with "B". The label "B" is used to identify those tubes of the outer group that have at least one inner tube as a nearest neighbor. Recall that in th described mbodiment the tubes supply gas to the gas distribution holes that are in bottom window 52.

[0037] To isolate the gas supply of the inner tubes from the gas supply of the outer tubes, no milled channels are permitted to pass from a tube opening labeled "B" to a tube opening labeled "A". To get the gas in to the inner tubes, one milled channel 210 extends from a supply hole-212 at the perimeter of the top plate to a tube hole within the inner array of tube holes. In the described embodiment, all of the tube holes through which this milled channel 210 passes also receive gas from this second source. Including gas distribution holes in the bottom window and aligned with the six tubes that lie along a radius extending from the outer perimeter of the top plate to the inner array of tubes is optional.

[0038] Of course, alternative approaches can be used to isolate the supplies to the two arrays of holes. For example, sets of channels can be milled in both the top and bottom plates, where one set of channels supplies the inner array and the other set of channels supplies the outer array.

[0039] Though we have used a dual-zone showerhead to illustrate this aspect of the invention, it should be understood that more than two zones can be constructed and that the zones can be configured in any shape that produces beneficial or useful results. For example, the showerhead can be divided into pie-shaped segments, with each segment supplied from a different gas source (see Fig. 7b). Or there can be multiple concentric zones surrounding a center zone (see Fig. 7a). The center zone may consist of a single center gas injection port, in which case the central gas flow component can be controlled independently of the overall gas flow through the showerhead.

Claims

1. A showerhead for use with a lamp head (40) in a thermal processing chamber (12), the lamp head including a high intensity source (44) which emits radiation that heats a substrate (16) within the chamber, said showerhead comprising:

    a top window (50) on a side of the showerhead that is, in use, adjacent to the lamp head;
    a bottom window (52) on a side of the showerhead that is, in use, adjacent to the substrate during processing; and
    a gas supply inlet (84) through which a gas is introduced into a space between the top and bottom windows,
    wher in the top and bottom windows are transparent to the radiation from the sourc in the lamp head and wh rein the bottom window includes a plurality of gas distribution holes (60) through which gas is injected from the space between the top and bottom windows, in use, into the chamber;

    characterised by a coolant structure providing a coolant flow path (98), at least a portion of which traverses and is in thermal contact with the bottom window (52).

2. The showerhead of claim 1, wherein the top (50) and bottom (52) windows are made of quartz.

3. The showerhead of claim 1, wherein the coolant structure comprises:

    a top plate (54) with a plurality of holes;
    a bottom plate (56) with a plurality of holes equal in number to the plurality of holes in the top plate; and
    a plurality of tubes (48) equal in number to the plurality of holes in the top plate, each of said plurality of tubes connecting a different one of the holes in the top plate to a corresponding one of the holes in the bottom plate; wherein the top window (50) is adjacent to the top plate and the bottom window (52) is adjacent to the bottom plate.

4. The showerhead of claim 1 or claim 2, wherein the coolant structure comprises:

    a top plate (54) with a plurality of holes;
    a bottom plate (56) with a plurality of holes equal in number to the plurality of holes in the top plate; and
    a plurality of tubes (48) equal in number to the plurality of holes in the top plate, each of said plurality of tubes connecting a different one of the holes in the top plate to a corresponding one of the holes in the bottom plate;
    wherein at least one of said top and bottom plates has an array of channels (80) formed therein for distributing the gas to the gas distribution holes (60) in the bottom window (52).

5. The showerhead of claim 4, wherein the top (54) and bottom (56) plates are made of stainless steel.

6. The showerhead of claim 5, wherein the tubes (43) are made of stainless steel.

7. The showerhead of claim 4, wherein the top (54) and bottom (56) plates are made of aluminum.

8. The showerhead of claim 5, wherein the tubes (48) of said plurality of tubes are made of aluminum.

9. The showerhead of claim 4, wherein the tubes (48) are covered on their inside surfaces with a highly reflective material.

10. The showerhead of claim 9, wherein the reflective material comprises gold.

11. The showerhead of claim 4, wherein the coolant structure includes a coolant inlet (90, 94,95) and a coolant outlet (92, 96, 97), and wherein during operation a coolant is circulated through the showerhead from the coolant inlet to the coolant outlet.

12. The showerhead of claim 11, wherein the coolant contacts the outside of the tubes (48).

13. The showerhead of claim 4, wherein said plurality of gas distribution holes (60) in the bottom window are grouped and aligned with the tubes (48).

14. A thermal processing system comprising:

a chamber (12) defining a processing cavity (14);
a lamp head (40);
a showerhead according to any one of the preceding claims positioned between the lamp head and the processing cavity in the chamber; and
a substrate support mechanism (18) within the chamber and spaced apart from the showerhead.

15. The thermal processing system of claim 14, wherein the showerhead also functions as an adapter for the lamp head (40).

16. The thermal processing system of claim 14, or 15. wherein the showerhead is mounted between the lamp head (40) and the chamber (12).

17. The thermal processing system of any of claims 14 to 16 further comprising a rotational drive (22) which, in use, rotates the substrate support mechanism (18) during processing.

18. The thermal processing system of claim 17, wherein the substrate support mechanism comprises a support ring (18) which holds the substrate (16) at locations around its perimeter.

19. The thermal processing system of claim 18, further comprising a reflecting plate (28) located beneath the support ring (18) which with a backside of the substrate defines a reflecting cavity (35).

20. A method of processing a substrate (16) in a thermal processing chamber comprising the steps of:

providing a top window (50) and a bottom window (52), wherein said top window is proximate to a light source (40) and said bottom window is proximate to the substrate (16) in the chamber;
directing radiation from the light source through the top and bottom windows and onto the substrate within the chamber to heat the substrate, wherein both the top and bottom windows are transparent to said radiation; and
while directing radiation through said top and bottom windows, also introducing a gas between the two windows and into the chamber through gas distribution holes (60) in the bottom window;

characterised by, while directing radiation and introducing said gas into the chamber, also flowing a coolant transversely across and in thermal contact with the bottom window.

21. The method of claim 20, wherein the step of flowing said coolant comprises flowing said coolant between the top (50) and bottom (52) windows.

22. The method of claim 20 or 21, wherein the step of flowing gas comprises flowing a reactive gas that is used processing of the substrate.

Patentansprüche

1. Duschkopf zur Verwendung mit einem Lampenkopf (40) in einer Wärmebehandlungskammer (12), wobei der Lampenkopf eine Quelle (44) hoher Intensität aufweist, die Strahlung emittiert, welche eine Substrat (16) in der Kammer erwärmt, und wobei der Duschkopf

- ein oberes Fenster (50) auf der Seite, die im Einsatz an den Lampenkopf angrenzt,
- ein unteres Fenster (52) auf der Seite, die bei seinem Einsatz an das Substrat während der Behandlung angrenzt, und
- einen Gaszuführeinlaß (84) aufweist, durch welchen ein Gas in den Raum zwischen dem oberen Fenster und dem unteren Fenster eingeführt wird,
- wobei das obere Fenster und das untere Fenster für die Strahlung aus der Quelle in dem Lampenkopf durchlässig ist und
- wobei das untere Fenster eine Vielzahl von Gasverteilungslöchern (60) hat, durch welche Gas aus dem Raum zwischen dem oberen Fenster und dem unteren Fenster während des

Einsatzes in die Kammer eingeblas n wird, gek nnzeichnet,

- durch ein Kühlsystem, mit einem Kühlmittelströmungsweg (98), von dem wenigstens ein Teil das untere Fenster (52) quert und mit ihm in Wärmekontakt steht.

2. Duschkopf nach Anspruch 1, bei welchem das obere Fenster (50) und das untere Fenster (52) aus Quarz bestehen.

3. Duschkopf nach Anspruch 1, bei welchem das Kühlsystem

- eine obere Platte (54) mit einer Vielzahl von Löchern,
- eine untere Platte (56) mit einer Vielzahl von Löchern, deren Anzahl der Vielzahl von Löchern in der oberen Platte entspricht, und
- eine Vielzahl von Rohren (48) aufweist, deren Anzahl der Vielzahl von Löchern in der oberen Platte entspricht,
- wobei jedes der Vielzahl von Rohren ein unterschiedliches Loch der oberen Platte mit einem_entsprechenden Loch in der unteren Platte verbindet und das obere Fenster (50) an die oberen Platte und das untere Fenster (52) an die untere Platte angrenzt.

4. Duschkopf nach Anspruch 1 oder Anspruch 2, bei welchem das Kühlsystem

- eine obere Platte (54) mit einer Vielzahl von Löchern
- eine untere Platte (56) mit einer Vielzahl von Löchern, deren Anzahl der Vielzahl von Löchern in der oberen Platte entspricht, und
- eine Vielzahl von Rohren (48) aufweist, deren Anzahl der Vielzahl von Löchern in der oberen Platte entspricht,
- wobei jedes der Vielzahl von Rohren ein unerschiedliches Loch in der oberen Platte mit einem entsprechenden Loch in der unteren Platte verbindet und
- wobei wenigstens die obere Platte oder die untere Platte eine Reihe von in ihr ausgebildeten Kanälen (80) zum Verteilen des Gases auf die Gasverteilungslöcher (60) in dem unteren Fenster (52) hat:

5. Duschkopf nach Anspruch 4, bei welchem die obere Platte (54) und die untere Platte (56) aus rostfreiem Stahl bestehen.

6. Duschkopf nach Anspruch 5, bei welchem die Rohre (43) aus rostfreiem Stahl bestehen.

7. Duschkopf nach Anspruch 4, bei welchem die obere Platte (54) und die untere Platte (56) aus Aluminium bestehen.

8. Duschkopf nach Anspruch 5, bei welchem die Rohre (48) der Vielzahl von Rohren aus Aluminium bestehen.

9. Duschkopf nach Anspruch 4, bei welchem die Rohre (48) auf ihren Innenflächen mit einem hoch reflektierenden Material überzogen sind.

10. Duschkopf nach Anspruch 8, bei welchem das reflektierende Material Gold aufweist.

11. Duschkopf nach Anspruch 4, bei welchem das Kühlsystem einen Kühlmitteleinlaß (90, 94, 95) und einen Kühlmittelauslaß (92, 96, 97) aufweist und während des Betriebs ein Kühlmittel durch den Duschkopf vom Kühlmitteleinlaß zum Kühlmittelauslaß umlaufen gelassen wird.

12. Duschkopf nach Anspruch 11, bei welchem das Kühlmittel die Außenseite der Rohre (48) kontaktiert.

13. Duschkopf nach Anspruch 4, bei welchem die Vielzahl von Gasverteilungslöchern (60) in dem unteren Fenster in Gruppen unterteilt und fluchtend zu den Rohren (48) ausgerichtet sind.

14. Wärmebehandlungssystem

- mit einer Kammer (12), die einen Behandlungshohlraum (14) begrenzt,
- mit einem Lampenkopf (40),
- mit einem Duschkopf nach einem der vorhergehenden Ansprüche, der zwischen dem Lampenkopf und dem Behandlungshohlraum in der Kammer angeordnet ist, und
- mit einem Substratträgermechanismus (18) in der Kammer der im Abstand von dem Duschkopf angeordnet ist.

15. Wärmebehandlungssystem nach Anspruch 14, bei welchem der Duschkopf auch die Funktion eines Adapters für den Lampenkopf (40) hat.

16. Wärmebehandlungssystem nach Anspruch 14 oder 15, bei welchem der Duschkopf zwischen dem Lampenkopf (40) und der Kammer (12) installiert ist.

17. Wärmebehandlungssystem nach einem der Ansprüche 14 bis 16, welches weiterhin einen Drehantrieb (22) aufweist, der bei seinem Einsatz den Substratträgermechanismus (18) während der Behandlung dreht.

18. Wärmebehandlungssystem nach Anspruch 17, bei welchem der Substratträgermechanismus einen Trägerring (18) aufw ist, der das Substrat (16) an Stellen um seinen Umfang herum hält.

19. Wärmebehandlungssystem nach Anspruch 18, welches weiterhin eine reflektierende Platte (28) aufweist, die unter dem Trägerring (18) angeordnet ist und mit der Rückseite des Substrats einen reflektierenden Hohlraum (35) bildet.

20. Verfahren zur Behandlung eines Substrats (16) in einer Wärmebehandlungskammer, welches die Schritte aufweist

- Bereitstellen eines oberen Fensters (50) und eines unteren Fensters (52), wobei sich das obere Fenster nahe an einer Lichtquelle (40) und sich das untere Fenster nahe an dem Substrat (16) in der Kammer befinden,
- Richten der Strahlung von der Lichtquelle durch das obere und das untere Fenster auf das Substrat in der Kammer zur Erwärmung des Substrats, wobei sowohl das obere als auch das untere Fenster für die Strahlung durchlässig sind, und
- Einführen eines Gases zwischen die beiden Fenster und in die Kammer durch Gasverteilungslöcher (60) in dem unteren Fenster gleichzeitig zum Richten der Strahlung durch das obere und das untere Fenster, gekennzeichnet
- durch Strömenlassen eines Kühlmittels quer über das untere Fenster und in Wärmekontakt damit gleichzeitig zum Richten der Strahlung und Einführen des Gases in die Kammer.

21. Verfahren nach Anspruch 20, bei welchem der Schritt des Strömenlassens des Kühlmittels das Strömenlassen von Kühlmittel zwischen dem oberen Fenster (50) und dem unteren Fenster (52) aufweist.

22. Verfahren nach Anspruch 20 oder 21, bei welchem der Schritt des Strömenlassens von Gas das Strömenlassen eines reaktiven Gases aufweist, das zur Behandlung des Substrats verwendet wird.

Revendications

1. Tête d'arrosage destinée à être utilisée avec un projecteur (40) dans une chambre (12) de traitement thermique, le projecteur comprenant une source (44) à haute intensité qui émet un rayonnement chauffant un substrat (16) à l'intérieur de la chambre, ladite tête d'arrosage comportant :

une fenêtre supérieure (50) sur un côté de la tête d'arrosage qui, lors de l'utilisation, est adjac nt au projecteur ;
une fenêtre inférieure (52) sur un côté de la tête d'arrosage qui, lors de l'utilisation, est adjacent au substrat pendant le traitement ; et
une entrée (84) d'alimentation en gaz à travers laquelle un gaz est introduit dans un espace situé entre les fenêtres supérieure et inférieure, dans laquelle les fenêtres supérieure et inférieure sont transparentes au rayonnement provenant de la source dans le projecteur et dans laquelle la fenêtre inférieure présente plusieurs trous (60) de distribution de gaz à travers lesquels un gaz est injecté depuis l'espace compris entre les fenêtres supérieure et inférieure, lors de l'utilisation, dans la chambre ;

caractérisée par une structure de refroidissement établissant un trajet (98) d'écoulement de fluide de refroidissement dont au moins une partie passe par la fenêtre inférieure (52) et est en contact thermique avec elle.

2. Tête d'arrosage selon la revendication 1, dans laquelle les fenêtres supérieure (50) et inférieure (52) sont réalisées en quartz.

3. Tête d'arrosage selon la revendication 1, dans laquelle la structure de refroidissement comporte :

une plaque supérieure (54) ayant plusieurs trous ;
une plaque inférieure (56) ayant plusieurs trous en nombre égal à celui des trous de la plaque supérieure ; et
une pluralité de tubes (48) en nombre égal à celui des trous de la plaque supérieure, chaque pluralité desdits tubes raccordant l'un, différent; des trous de la plaque supérieure à l'un, correspondant, des trous de plaque inférieure ;
dans laquelle la fenêtre supérieure (50) est adjacente à la plaque supérieure et la fenêtre inférieure (52) est adjacente à la plaque inférieure.

4. Tête d'arrosage selon la revendication 1 ou la revendication 2, dans laquelle la structure de refroidissement comporte :

une plaque supérieure (54) ayant plusieurs trous ;
une plaque inférieure (56) ayant plusieurs trous en nombre égal à celui des trous de la plaque supérieure ; et
plusieurs tubes (48) en nombre égal à celui des trous de la plaque supérieure, chacun desdits tubes raccordant l'un, différent, des trous de la

plaque supérieure à l'un, correspondant, des trous de la plaque inférieure ;
dans laquelle au moins l'une desdites plaques supérieure et inférieure comporte un réseau de canaux (80) formés dans cette plaque pour distribuer le gaz vers les trous (60) de distribution de gaz dans la fenêtre inférieure (52).

5. Tête d'arrosage selon la revendication 4, dans laquelle les plaques supérieure (54) et inférieure (56) sont réalisées en acier inoxydable.

6. Tête d'arrosage selon la revendication 5, dans laquelle les tubes (43) sont réalisés en acier inoxydable.

7. Tête d'arrosage selon la revendication 4, dans laquelle les plaques supérieure (54) et inférieure (56) sont réalisées en aluminium.

8. Tête d'arrosage selon la revendication 5, dans laquelle les tubes (48) de ladite pluralité de tubes sont réalisés en aluminium.

9. Tête d'arrosage selon la revendication 4, dans laquelle les tubes (48) sont recouverts sur leurs surfaces intérieures d'une matière hautement réfléchissante.

10. Tête d'arrosage selon la revendication 9, dans laquelle la matière réfléchissante comprend de l'or.

11. Tête d'arrosage selon la revendication 4, dans laquelle la structure de refroidissement comprend une entrée (90, 94, 95) de fluide de refroidissement et une sortie (92, 96, 97) de fluide de refroidissement, et dans laquelle, pendant le fonctionnement, un fluide de refroidissement est mis en circulation à travers la tête d'arrosage de l'entrée de fluide de refroidissement à la sortie de fluide de refroidissement.

12. Tête d'arrosage selon la revendication 11, dans laquelle le fluide de refroidissement entre en contact avec le côté extérieur des tubes (48).

13. Tête d'arrosage selon la revendication 4, dans laquelle ladite pluralité de trous (60) de distribution de gaz dans la fenêtre inférieure sont groupés et alignés avec les tubes (48).

14. Système de traitement thermique comportant :

une chambre (12) définissant une cavité de traitement (14) ;
un projecteur (40) ;
une tête d'arrosage selon l'une quelconque des revendications précédentes positionné entre le projecteur et la cavité de traitement dans la chambre ; et
un mécanisme (18) de support de substrat à l'intérieur de la chambre et espacé de la tête d'arrosage.

15. Système de traitement thermique selon la r vendication 14, dans lequel la tête d'arrosage fonctionne également en tant qu'adaptateur pour le projecteur (40).

16. Système de traitement thermique selon la revendication 14 ou 15, dans lequel la tête d'arrosage est montée entre le projecteur (40) et la chambre (12).

17. Système de traitement thermique selon l'une quelconque des revendications 14 à 16, comportant en outre un moyen d'entraînement en rotation (22) qui, lors de l'utilisation, fait tourner le mécanisme (18) de support de substrat pendant le traitement.

18. Système de traitement thermique selon la revendication 17, dans lequel le mécanisme de support de substrat comporte un anneau de support (18) qui maintient le substrat (16) en des points situés le long de son périmètre.

19. Système de traitement thermique selon la revendication 18, comportant en outre une plaque réfléchissante (28) placée en dessous de l'anneau de support (18), avec laquelle un côté arrière du substrat défini une cavité réfléchissante (35).

20. Procédé de traitement d'un substrat (16) dans une chambre de traitement thermique, comprenant les étapes dans lesquelles :

on utilise une fenêtre supérieure (50) et une fenêtre inférieure (52), ladite fenêtre supérieure étant proche d'une source de lumière (40) et ladite fenêtre inférieure étant proche du substrat (16) dans la chambre ;
on dirige un rayonnement depuis la source de lumière à travers les fenêtres supérieure et inférieure et jusque sur le substrat à l'intérieur de la chambre pour chauffer le substrat, les deux fenêtres supérieure et inférieure étant transparentes audit rayonnement ; et
pendant qu'on dirige un rayonnement à travers lesdites fenêtres supérieure et inférieure, on introduit également un gaz entre les deux fenêtres et dans la chambre en passant par des trous (60) de distribution de gaz situés dans la fenêtre inférieure ;

caractérisé par le fait que, tandis qu'on dirige un rayonnement et qu'on introduit ledit gaz dans la chambre, on fait également circuler un fluide de re-

froidissement transversalement à la fenêtre inférieure et en contact thermique avec elle.

21. Procédé selon la revendication 20, dans lequel l'étape consistant à faire circul r ledit fluide de refroidissement comprend la circulation dudit fluide de refroidissement entre les fenêtres supérieure (50) et inférieure (52).

22. Procédé selon la revendication 20 ou 21, dans lequel l'étape consistant à faire circuler un gaz comprend la circulation d'un gaz réactif qui est utilisé dans le traitement du substrat.

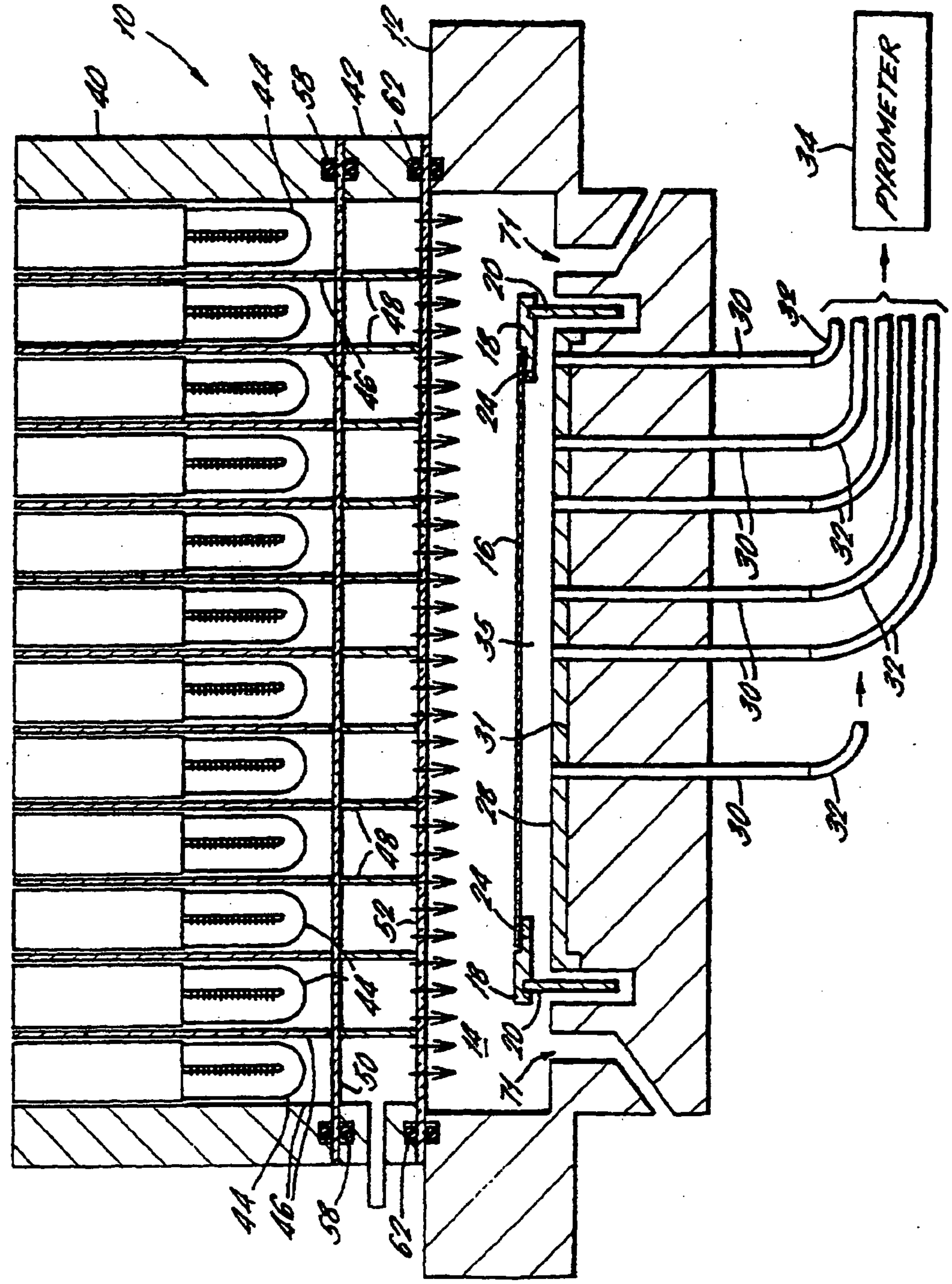
PYROMETER
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FIG. 1.

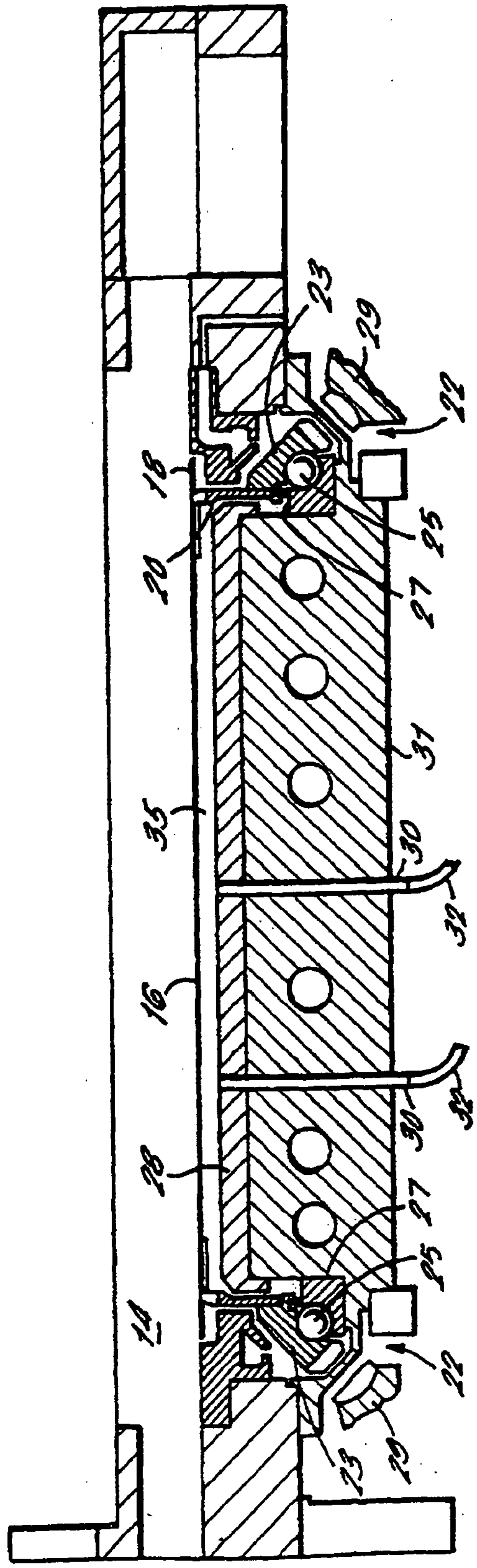

FIG. 2.

FIG. 3.

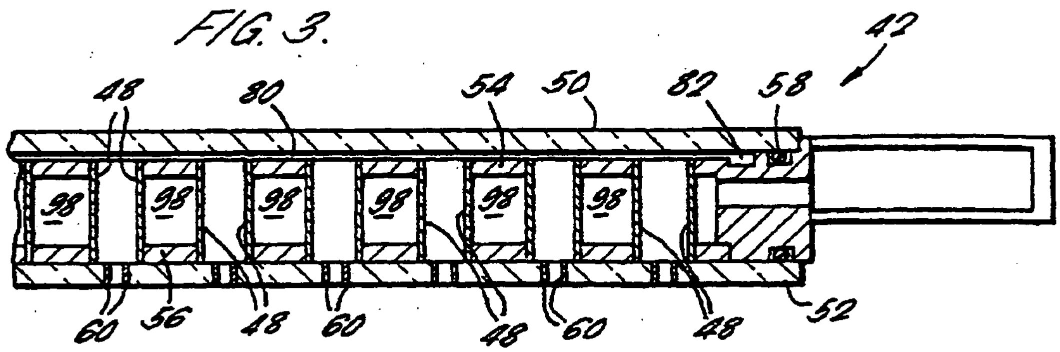

FIG. 4.

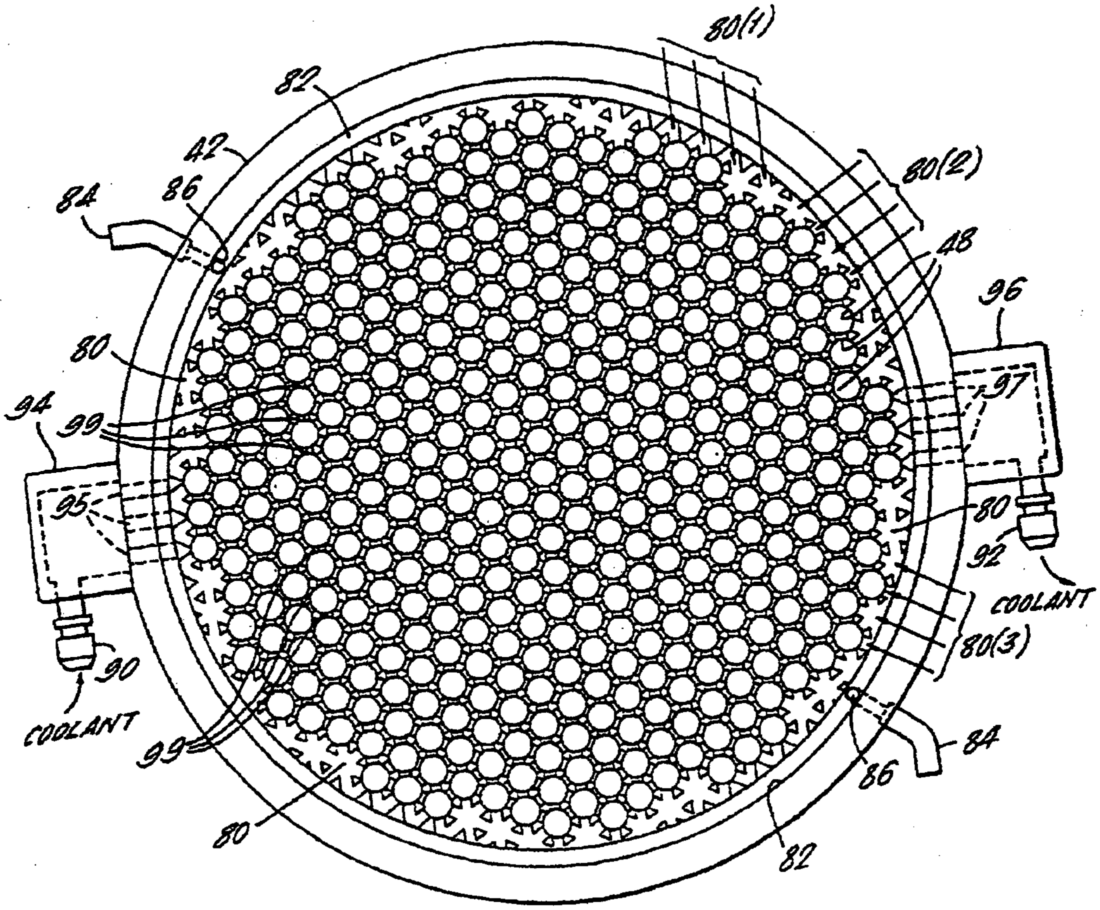
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FIG. 5.

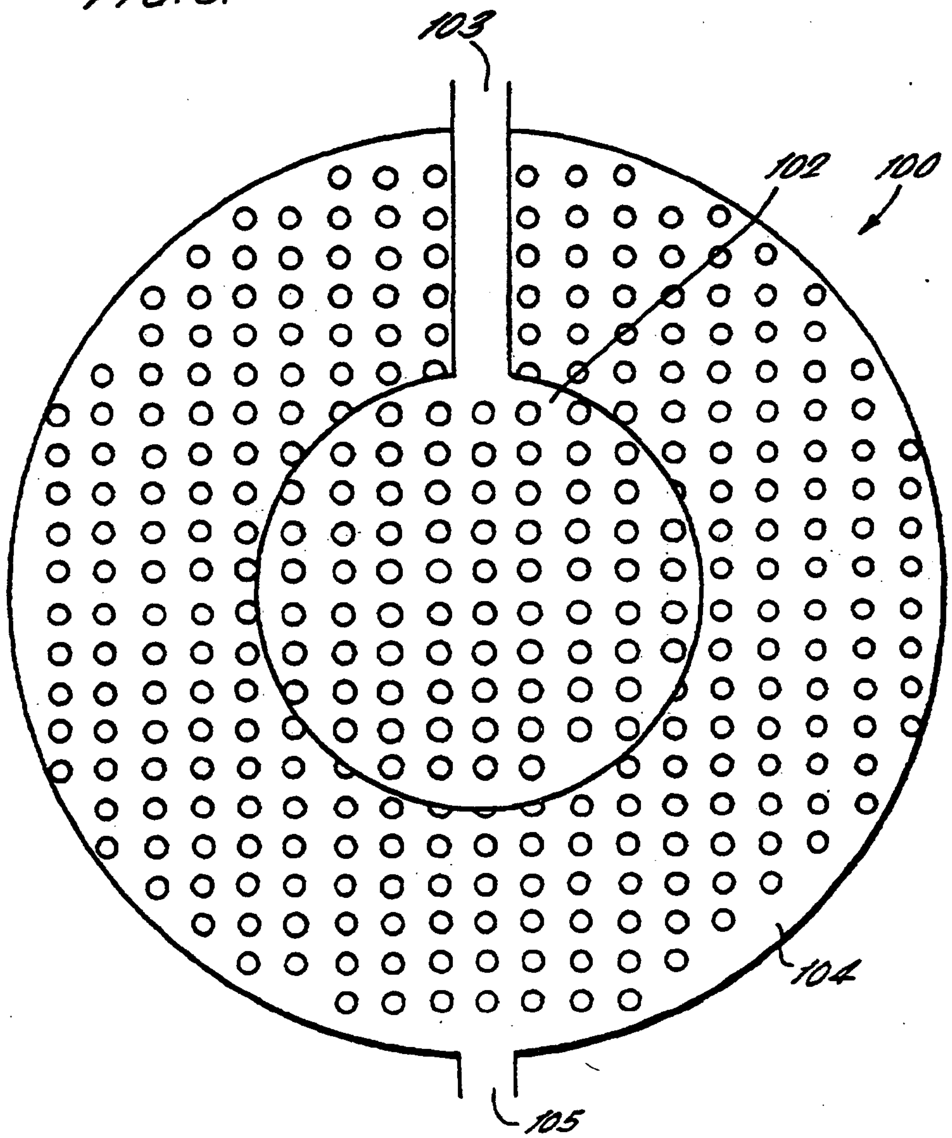

FIG. 6.

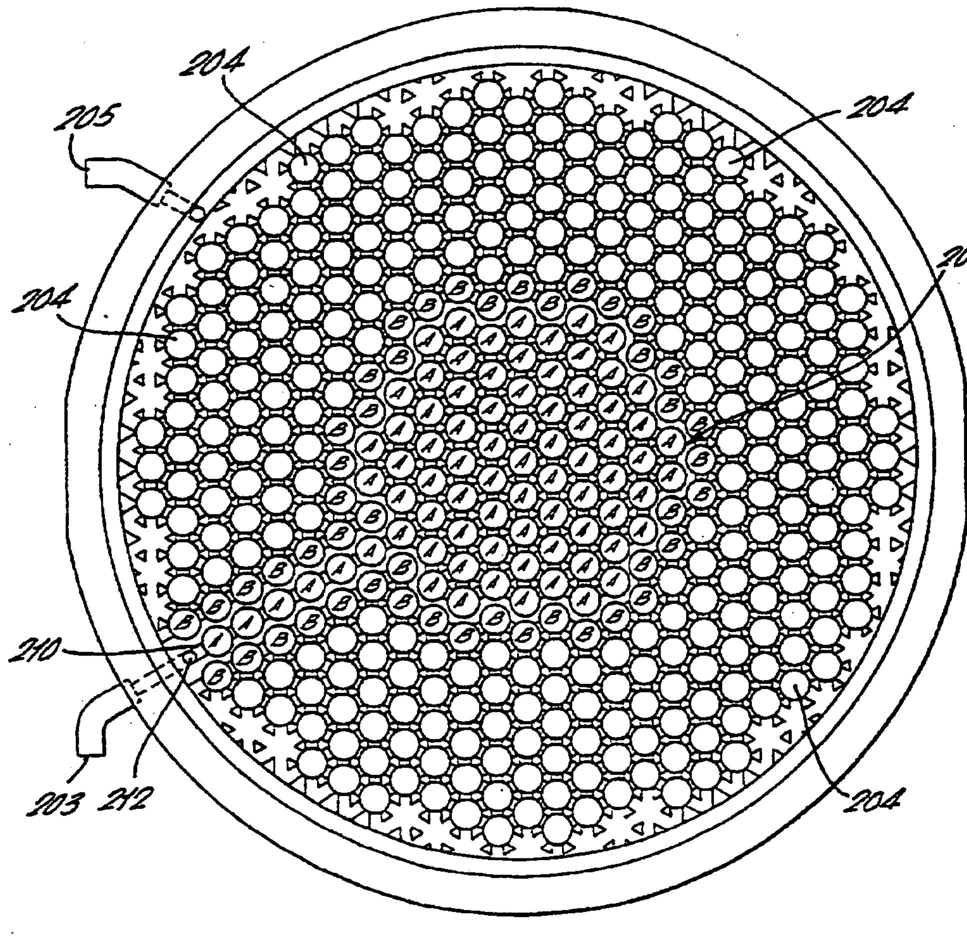

FIG. 7a.

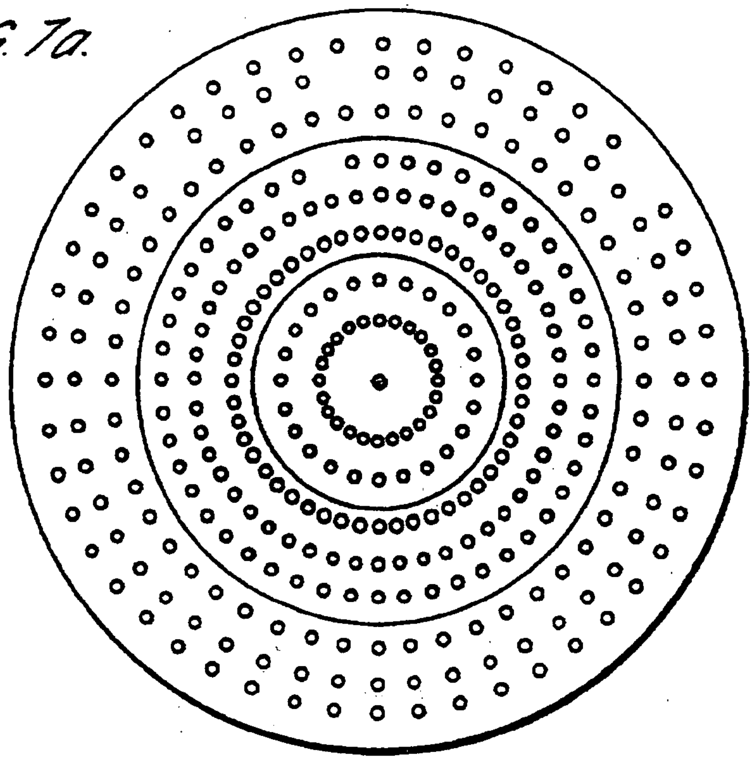

FIG. 7b.